

## *Entoloma ravinense* (Agaricales, Basidiomycota), a new species from South Australia

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### Abstract.

*Entoloma ravinense*, a new species of *Entoloma* subgenus *Claudopus*, section *Claudopus*, is described. The species differs from other white laterally attached (pleurotoid) species of *Entoloma* in its larger fruit bodies, close lamellae, and larger basidia, and has internal transcribed spacer (ITS) and nuclear ribosomal RNA large subunit (28S) sequences that differ from all those available for other species of the genus. Descriptions and illustrations of *E. ravinense* are presented and comparisons made with other pleurotoid taxa in the subgenus. A key to Australian species of pleurotoid entolomas is provided.

**Key words:** *Entoloma*, subgenus *Claudopus*, section *Claudopus*, pleurotoid habit, wet sclerophyll habitat, Kangaroo Island, South Australia.

### Introduction.

The genus *Entoloma* (Fr.) P.Kumm. is represented by at least 1000 species worldwide (Kirk et al. 2008) and has been shown to be monophyletic (Matheny et al. 2006; Co-David et al. 2009). The subgenus *Claudopus* Gillet is considered to be an independent genus by some researchers (Horak 1980, 2008; Largent et al. 2011; Pegler 1986). Others (Noordeloos 1981, 1992, 2004, 2012; Manimohan et al. 2006) consider that the largely pleurotoid habit does not provide justification for the generic rank since there are pleurotoid taxa within other clades such as the *linocephalus-cyanula* clade (Noordeloos & Gates 2012). Although *Entoloma* is a very large and morphologically variable genus, maintaining it as a single genus provides a stable classification that is consistent with phylogeny (Co-David et al. 2009). This paper follows the concept that *Claudopus* is a subgenus within the genus *Entoloma*.

Most species in the section *Claudopus* Noordel. are characterised by their pleurotoid habit with an initially central stipe that becomes excentric to lateral or disappears as the pileus expands (Noordeloos 1987, 1988, 2004, 2012). Some in that section are omphaloid, having a small stature and central stipe, but these will not be discussed in this paper.

The pleurotoid entolomas are often overlooked, in part due to often occurring in cryptic places, such as the underside of rocks, and their usually small size. Most are saprotrophic, growing on dead, often rotten wood and bark, on debris of grasses and sedges, on the ground or on mosses, but occasionally they are parasitic on fungi, such as species of *Cantharellus* Adans. ex Fr.

Species in the subgenus *Claudopus* are considered to be rare, the number currently amounting to no more than approximately 25. Noordeloos (2004) reported ten species from Europe, Horak (1980) reported five from Indomalaya and Australia and *Claudopus byssisedus* (Pers.:Fr.) Gillet (syn. *Entoloma byssisedum* (Pers.:Fr.) Donk) from New Zealand. Previous to 2011, authentic Australian material existed only for *Entoloma byssisedum* (May & Wood 1997). Since then, three saxicolous species have been described, *Claudopus rupestris* Largent & Abell-Davis, *C. viscosus* Largent & Abell-Davis, *C. minutoincanus* Largent & Abell-Davis (Largent et al. 2011) and *Entoloma pitereka* Noord. & G.M.Gates from Tasmania, growing on the underside of rotten wood in wet eucalypt forest (Noordeloos & Gates 2012).

The Ravine des Casoars Wilderness Protection Area, Kangaroo Island, where the fungus reported in this paper was found, is a steep sided valley vegetated by *Eucalyptus cladocalyx* F.Muell. and *E. diversifolia* Bonpl. sclerophyll forest. The area was burnt during severe bushfires in December 2007. The vegetation is now regenerating and the area is densely covered with *Acacia paradoxa* DC. In both June 2010 and June 2014, fruit bodies were collected growing on the underside of shed bark of *E. cladocalyx*. In 2010 a dozen fruit bodies were found, scattered over bark measuring approximately 15 × 10 cm (Figs. 1 & 2); in 2014 only three fruit bodies were found, again on a similar sized piece of bark. The area was searched thoroughly but no further fruit bodies were found. A further collection of seven fruit bodies was made in 2015, again on very rotten shed *E. cladocalyx* bark.



Fig. 1. Fruit bodies of the holotype of *Entoloma ravinense* in situ. — Photo: D.E.A. Catcheside, 24 June 2010.

The *Entoloma* species found on 24 June 2010 (PSC 3331, AD-C 56995) was the millionth specimen to be accessioned into the State Herbarium of South Australia (AD) and is therefore of considerable significance to that herbarium.

## Materials and Methods

### Morphology

Habitat and associated plant communities were noted in the field. Collection locations were recorded by GPS (Garmin GPS12) and in situ photographs and micrographs taken using a Nikon 4500 camera. Macroscopic characters were described directly from fresh material. Colours are described in general terms and more precisely according to Komerup & Wanscher (1978) (page number, column letter, row number, e.g. 2B4). Fresh material was dried in a food dehydrator at 35°C for 24 h (Hydraflo 1000FD).

The number of lamellae per fruit body is given as L. Hand-cut sections of fresh and dried material were mounted in 5% aqueous solution of KOH, then stained with ammoniacal Congo Red. To determine the amyloid reaction, fresh material was directly stained with Melzer's reagent, dried material was rehydrated in 5% ammonium hydroxide before staining with Melzer's reagent. Measurements were made at  $\times 400$  or  $\times 1000$  with a calibrated ocular micrometer. Spore dimensions are given as length range  $\times$  width range ( $n = 40$ ). The length:width ratio ( $Q$ ) of individual spores is presented as the range of  $Q$  values and the mean  $Q$ . Measurements do not include the apiculus. Basidia dimensions are given as length range  $\times$  width range ( $n = 20$ ). Illustrations and descriptions are in terms of structures visible by light microscopy. All macro- and microphotographs are from the type material PSC3331, AD-C 56995. A small section of lamellar tissue from all specimens in the collection was examined to ascertain that all were of the same taxon. All collections have been accessioned into the State Herbarium of South Australia (AD).



Fig. 2. Mature fruit bodies of the holotype of *Entoloma ravinense* in situ. — Photo: D.E.A. Catcheside, 24 June 2010.

Collections of *Entoloma pitereka* and *E. byssisedum* from Hobart (HO), Melbourne (MEL) and Perth (PERTH) herbaria were examined as well as the South Australian collections. A small section of lamellar tissue was taken from one specimen from each collection and measurements were made of spores ( $n = 40$ ) and basidia ( $n = 20$ ). To avoid further destruction of tissue, the pileipellis was not examined.

### Molecular

DNA was extracted from 5–10 mg of dried specimens by freezing with liquid nitrogen and grinding in a pestle and mortar with 500  $\mu$ l of pH 8.0 isolation buffer (50 mM Tris-HCl, 170 mM EDTA, 1% N-lauroylsarcosine). The frozen paste was allowed to thaw, transferred to a 1.5 ml Eppendorf tube and incubated at 65°C for 5 min. Following addition of 300  $\mu$ l 7.5 M ammonium acetate, tubes were mixed by inversion, incubated on ice for 10 min and centrifuged at 13,000 g for 5 min. The supernatant (700  $\mu$ l) was transferred to a fresh tube, mixed with 500  $\mu$ l of isopropanol and held on ice for 10 min. Following centrifugation at 13,000 g for 3 min the supernatant was discarded and tubes drained by inversion on paper towel. The pellet was dissolved in 250  $\mu$ l Tris EDTA buffer (10 mM Tris 1mM EDTA pH 8.0), if necessary by incubation at 50°C for 5 min and brief vortex mixing. PCR amplifications (50  $\mu$ l) used Phusion polymerase (New England Biolabs) in HF buffer, ITS1, ITS4, LR0R and LR5 primers, as appropriate for the internal transcribed spacer (ITS) and nuclear ribosomal RNA large subunit (28S) respectively (White et al. 1990) and 1  $\mu$ l of a 1/20 or 1/100 dilution of the DNA extract. Amplification used 5 min at 98°C followed by 40 cycles (98°C 30 s, 55°C 15 s, 72°C 15 s) then 5 min at 72°C prior to storage at 4°C. PCR products were purified using a PCK-1 kit (AdBiotec) and sequenced (AGRF) on both strands with appropriate primers. As amplicons from *E. pitereka* specimens included mould sequences, the required PCR products were excised from gels and recovered using a QIAquick





Fig. 3. Fruit bodies of the holotype of *Entoloma ravinense* in the laboratory before drying. — Photo: D.E.A. Catcheside, 24 June 2010.

gel extraction kit. DNA sequence assembly from paired reads was checked manually for consistency and for heterozygous sites. Blastn searches for related sequences in GenBank employed NCBI software. Phylogenetic analysis used Geneious 8.1.8 software, MUSCLE for alignment and MrBayes for tree construction using the HKY85 substitution model, 4 heated chains for 1,100,000 iterations including a burn in of 100,000.

## Results

### Taxonomy

***Entoloma ravinense*, P.S.Catches., Vonow & D.E.A.Catches., sp. nov.**

**Holotype:** South Australia. Kangaroo Island: North facing slope of Ravine des Casoars Wilderness Area, 35° 48' 8.5"S, 136° 36' 43"E, alt. c. 45 m, in *E. cladocalyx* F.Muell. and *E. diversifolia* Bonpl. woodland with *Acacia paradoxa* DC, on wood, underside of bark of *Eucalyptus cladocalyx* F.Muell, 24 June 2010, P.S. Catcheside, D.E.A. Catcheside & H.P. Vonow PSC 3331 (AD-C 56995).

**Mycobank number:** MB817471.

*Basidiomata* few, scattered to occasionally clumped. Pleurotoid or crepidotoid, with stipe lacking, excentric or lateral (Figs. 1, 2, 3). *Pileus* 5–63 mm diameter,

3–33 mm anteriorly-posteriorly, 1–5 mm high; convex to broadly applanate, circular to fan-shaped when young, becoming semicircular, then reniform; white 4A1 (Kornerup & Wanscher); softly hairy, felty, downy-woolly to tomentose; not hygrophanous, not translucently striate; dry; margin inrolled. *Lamellae* adnexed but distant from top of stipe, radiating from attachment if stipe absent; close, L = 25–60; ventricose; white 4A1 to cream 4A2 when young, becoming pink 5A2 then finally translucent tan 5B4–5 to 5C4; margin concolourous, entire; 2–3 series of lamellulae. *Stipe* absent, substipitate to short-stipitate, lateral or excentric; if present, bent, curving, length 3–5 mm, diameter 2–3 mm; white 4A1 to cream 4A2; finely tomentose. Basal rhizomorphs extensive, forming a subiculum. *Smell and taste* not recorded. *Spore print* pale pink fawn, pinkish tan, 6C4. *Spores* (Fig. 4) 8.0–10.5 × 6.5–8.0 µm, mean 8.26 × 6.95 µm; Q = 1.11–1.44 (–1.56), mean Q = 1.31 (n = 40); 5–7 (8) angled in side view, isodiametric, mostly heterodiametric; inamyloid; hyaline; with one large guttule. *Basidia* (Fig. 5) 38–46 × 8–11 (–12) µm, mean 41.35 × 10.1 µm; clavate; 4-spored; clamp connections not seen. *Cheilocystidia* absent. *Lamella edge* fertile. *Hymenophoral trama* regular, of cylindrical hyphae 3–10 µm diameter. *Pileipellis* (Figs. 6, 7, 8)



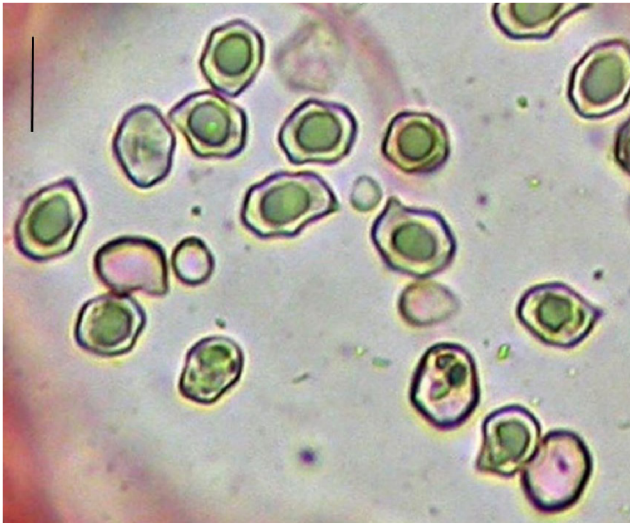


Fig. 4. Spores of *Entoloma ravinense*. Scale bar = 10  $\mu$ m. — Holotype. Photo: P.S. Catcheside, 16 Dec. 2010.

in centre a cutis of interwoven, entangled, cylindrical hyphae, with transition to a trichoderm towards margin; hyphal ends of trichoderm growing perpendicularly to pileipellis, terminal elements 10–25 (–37)  $\times$  (5–) 7–12 (–15)  $\mu$ m, apices rounded; some hyphae in lower layers with encrustations; clamps absent. *Pileitrama* regular, similar to hymenophoral trama. *Stipitipellis* a cutis of irregular repent hyphae 3–10  $\mu$ m diameter, with clusters of upright hyphae, terminal ends of hyphae measuring 30–40 (–55)  $\times$  4–10 (–14)  $\mu$ m. *Clamp connections* not found in any tissue.

*Etymology.* The specific epithet refers to the type location, the Ravine des Casoars.

#### *Additional specimens examined.*

**SOUTH AUSTRALIA. Kangaroo Island:** North facing slope of Ravine des Casoars Wilderness Area, 35° 48' 5" S, 136° 36' 50" E, alt. c. 45 m, in *E. cladocalyx* F.Muell. and *E. diversifolia* Bonpl. woodland with *Acacia paradoxa* DC., on wood, underside of bark of *E. cladocalyx*, 24 June 2014, P.S. Catcheside, D.E.A. Catcheside & H.P. Vonow PSC3960 (AD-C 58774); Location near to collections PSC3331 and PSC3960, 35° 48' 8.7" S, 136° 36' 48" E, on similar substrate and in similar plant community, 22 June 2015, P.S. Catcheside, D.E.A. Catcheside & H.P. Vonow PSC4229 (AD-C 59843).

#### *Other species examined.*

#### *Entoloma pitereka* Noordel. & G.M. Gates.

**TASMANIA.** Wielangta, 42° 42' S, 147° 51' E, 19 Feb. 2005, G. Gates *E* 2081 (HO 564359; holotype); Duckhole Lane Track, 43° 22' S, 146° 53' E, substrate: wood, habitat: wet sclerophyll, 25 Jan. 2007, G.M. Gates & D.A. Ratkowski 1733 (MEL 2363720); Growling Swallett, 42° 41' S, 146° 30' E, substrate: wood, habitat: wet sclerophyll, 1 Jan. 2008, G.M. Gates & D.A. Ratkowski 1747 (MEL 2363723).

#### *Entoloma byssisedum* (Pers.) Donk.

**WESTERN AUSTRALIA.** On old wood, Wanneroo, 31° 45' 0" S, 115° 48' 0" E, 24 Sep. 1978, J. Daams s.n. (PERTH 00938424); On very rotten wood just protruding from heap of earth, pine plantation, by gate to old Carinyah Pine Plantation, Karragullen (now MWB), 32° 05' 0" S, 116° 07' 0" E, 29 June 1983, R.N. Hilton s.n. (PERTH 00917354).



Fig. 5. Basidia of *Entoloma ravinense*. Stained in Congo Red. Scale bar = 10  $\mu$ m. — Holotype. Photo: P.S. Catcheside, 29 Jan. 2015.

#### Molecular data

A contig of 1588 bp was obtained for *Entoloma ravinense* PSC3331 (GenBank accession KX387622) covering 18S partial sequence, ITS1, 5.8S and ITS2 complete sequence and 28S partial sequence from nuclear ribosomal genes. For *E. pitereka* MEL236370, a contig of 618 bp (GenBank accession KX387621) covering ITS1 partial sequence, 5.8S and ITS2 complete sequence and another of 905 bp (GenBank accession KX387620) covering part of the 28S gene were obtained.

The 596 bp ITS-5.8S rRNA-ITS2 sequence from *E. ravinense* was used to extract 500 related sequences from GenBank on 17 March 2016. The list obtained was reduced to the 213 *Entoloma* sequences including *E. ravinense* and *E. pitereka*, aligned and trimmed to 787 bp, including gaps, prior to tree building. For the tree constructed from nuclear ribosomal large subunit sequences, GenBank was searched for *Entoloma*, *Nolanea* and *Claudopus* sequences on 21 May 2016. The list obtained was edited to include *E. ravinense*, *E. pitereka* and the 302 other sequences covering  $\geq$  512 bp of 28S RNA, aligned and trimmed to 678 bp including gaps prior to tree building. Trees constructed from alignments of both sets of sequences show both *E. ravinense* and *E. pitereka* are members of the subgenus *Claudopus* of *Entoloma* (Figs. 9, 10). The full list of sequences included in the analysis is available from the authors.

#### Discussion

*Claudopus* is a recognised subgenus of *Entoloma* and forms a clade within *Entoloma* in phylograms based on either 28S or ITS sequences (Figs. 9, 10). Both *E. ravinense* and *E. pitereka* fall within this clade, which Co-David et al. (2009) recognise also contains species formerly assigned to the genus *Nolanea* (Fr.) P.Kumm. In the 28S tree, *E. ravinense* and *E. pitereka* are in different subclades, which also include other Australian species, while in the ITS tree, *E. pitereka* is basal to all



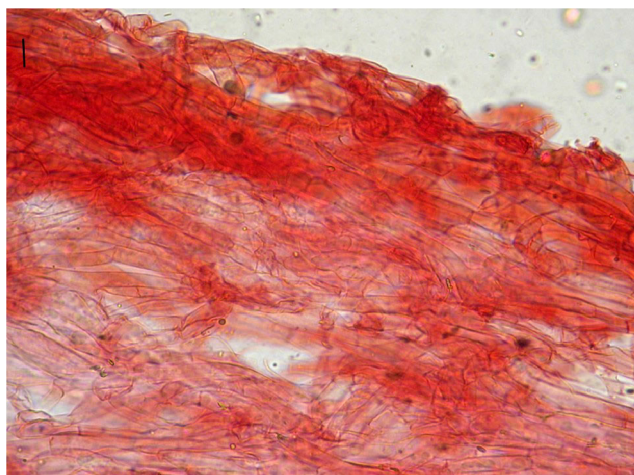


Fig. 6. Pileipellis of *Entoloma ravinense* in centre of pileus. Stained in Congo Red. Scale bar = 10  $\mu$ m. — Holotype. Photo: P.S. Catcheside, 27 Apr. 2015.

other species of subgenus *Claudopus*, and *E. ravinense* groups with sequences of *E. shandongense* T.Bau & J.R.Wang from China and India and an *E. byssisedum* sequence from Spain.

*Entoloma ravinense* may be distinguished from other white laterally attached (pleurotoid) species of *Entoloma* by its larger and sparse fruit bodies, close lamellae with usually three series of lamellulae, and its larger basidia (Tables 1 & 2). The margin of its pileus is distinctly inrolled, and is densely covered with fine white, woolly hairs. Its stipe is tomentose with a tangle of white mycelial threads proliferating from its base and forming an extensive subiculum or mat. No clamp connections were found, not even at the bases of immature basidia, in spite of an extensive search. Its substrate, fallen bark, also differs from many other white, pleurotoid entolomas.

The only taxa of pleurotoid *Entoloma* that have been described previously from Australia are *Claudopus minutocanus*, *C. rupestris*, *C. viscosus* and *Entoloma pitereka*, and there is a record by Hilton (1988) of *E. byssisedum*, first described from the Northern Hemisphere. The last species differs from the other four in being pale grey to grey-brown and will be discussed among the non-white members of the subgenus *Claudopus*.

The first three species all grow on the undersides of granitic rocks. They produce abundant fruit bodies, all having white, sticky, small pilei with the largest, *C. viscosus*, having pileus diameter 1.5 to 11 mm (Largent et al. 2011). In contrast, *Entoloma ravinense* grows on the underside of bark, produces few fruit bodies (the most we have found in a location is twelve), the pilei are dry and diameters range from 5 to 63 mm. Microscopically, *Claudopus minutocanus*, *C. rupestris*, *C. viscosus* and *Entoloma ravinense* are similar in the absence of clamp connections and spore dimensions but *E. ravinense* has larger basidia ( $38\text{--}46 \times 8\text{--}11\text{--}(12) \mu\text{m}$ ), while those of the largest of the saxicolous taxon, *Claudopus minuto-*

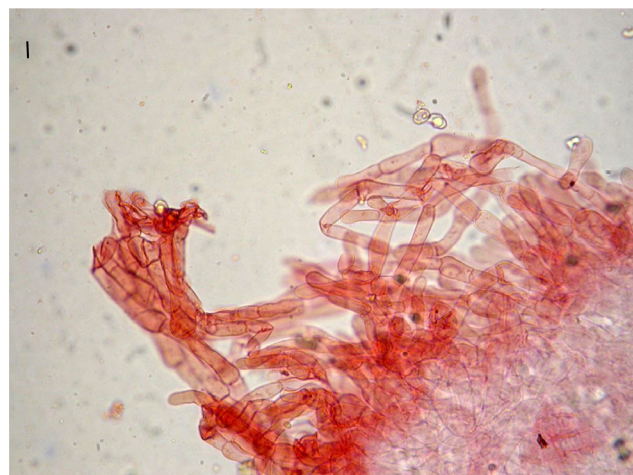


Fig. 7. Pileipellis of *Entoloma ravinense* towards margin. Stained in Congo Red. Scale bar = 10  $\mu$ m. — Holotype. Photo: P.S. Catcheside, 27 Apr. 2015.

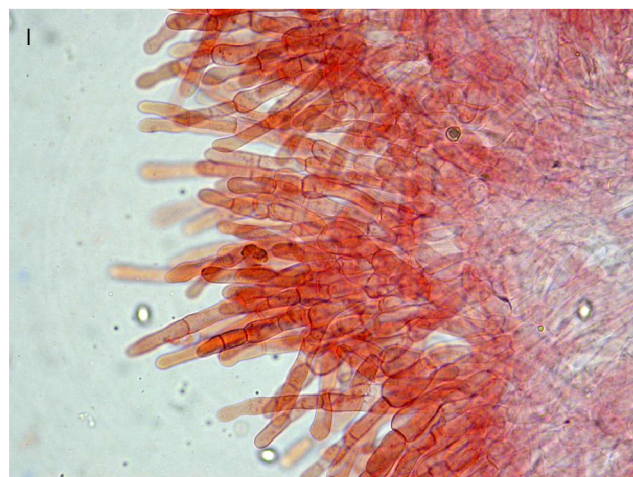
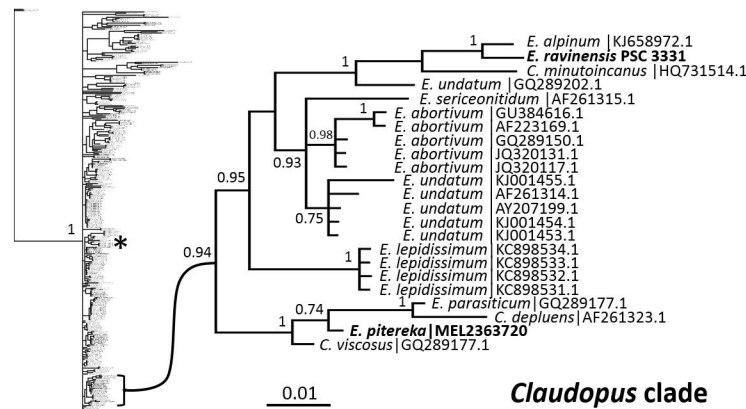


Fig. 8. Pileipellis of *Entoloma ravinense* at margin. Stained in Congo Red. Scale bar = 10  $\mu$ m. — Holotype. Photo: P.S. Catcheside, 27 Apr. 2015.

*incanus*, are shorter ( $32.7\text{--}38.3 \mu\text{m}$ ) and broader ( $9.8\text{--}13.3 \mu\text{m}$ ).

*Entoloma pitereka* is described as growing in troops on the underside of rotten wood, a somewhat similar substrate to that of *E. ravinense*. The latter species seems to produce no more than three fruit bodies in one clump. Pilei of *E. pitereka* are smaller (1–15 mm diameter), lamellae are subdistant with mostly one series of lamellulae, while *E. ravinense* is larger (5–63 mm) and has close lamellae with mostly three series of lamellulae. Pileus margins of *E. ravinense* are distinctly inrolled at first and remain inrolled, while those of *E. pitereka* are only slightly inrolled and appear to become plane with age. The whole surface of *E. ravinense*, particularly at the margin, is distinctly hairier than that of *E. pitereka*. Microscopically the species have similar spore dimensions, although spores of *E. pitereka* may reach a greater length (*E. pitereka*:  $8\text{--}12 \times 6\text{--}8 \mu\text{m}$ , *E. ravinense*  $8\text{--}10.5 \times 6.5\text{--}8 \mu\text{m}$ ) and also have a greater length:width ratio (mean  $Q = 1.42$ ,  $n = 20$ ), compared with that for



**Fig. 9.** Phylogram from Bayesian analysis of *Entoloma* nuclear rRNA 28S large subunit sequences group *E. ravinense* and *E. pitereka* in the *Claudopus* clade. Figures show the posterior probability of relevant branches. The scale of substitutions per site applies only to the *Claudopus* clade. The asterisk marks the position of the sequence for *C. rupestris* [HQ731515.1 (Largent et al. 2011), which falls outside this clade. Accession numbers for GenBank follow ]. The phylogram is rooted to the GenBank sequence for *E. pamela* Largent [KJ021702].

*E. ravinense* (mean  $Q = 1.31$ ,  $n = 40$ ). The hyphae of the pileipelli of both species are similar, though fewer of the terminal endings of the hyphae of *E. ravinense* were observed to be swollen. However many of the hyphae of its stipe pellis do have swollen, subcapitate terminal endings. In spite of extensive searching in the tissues of *E. ravinense*, no cheilocystidia were found, nor clamp connections, not even at the bases of basidioles. Cheilocystidia were sometimes found in *E. pitereka*, as were clamp connections, although only at the bases of basidia. Basidia of *E. ravinense* are considerably longer ( $38\text{--}46 \times 8\text{--}11$  ( $-12$ )  $\mu\text{m}$ ), in comparison with those of *E. pitereka* ( $28\text{--}34 \times 9\text{--}11$   $\mu\text{m}$ ).

Other white pleurotoid *Entolomas* that have been described are *E. albotomentosum* Noordel. & Hauskn., *E. alliodorum* Esteve-Rav., E. Horak & A. Ortega, *E. exiguum* Esteve-Rav. & M.de la Cruz, *E. jahnii* Wölfel & Winterh. and *E. parasiticum* (Qué.) Kreisel. All are much smaller than *E. ravinense*: the largest, *E. jahnii* recorded as 1–15 mm diameter (Schafer 2008; Nita & Stefaniak 2010; Jančovičová & Adamčík 2012; Noordeloos 2012). Although none have been recorded in Australia, differences between these and *E. ravinense* will be discussed. Noordeloos (2004) commented that in the past few years the number of known *Claudopus* species in Europe has doubled. He suggested that this was due to increased sampling, especially in habitats such as marshy places, not usually associated with rich fungal diversity. It is highly likely that, with the growing awareness and collecting of fungi, the same will apply in Australia.

*Entoloma ravinense* was found fruiting on the underside of shed bark of *Eucalyptus cladocalyx* in eucalypt woodland. *Entoloma albotomentosum*, *E. alliodorum* and *E. exiguum* have different habitats and substrates. *Entoloma albotomentosum* occurs in marshy places on damp rotten debris of sedges, grasses and herbaceous plants (Halama 2011), *E. alliodorum*, which smells of garlic, grows on organic debris among moss, lichens and very rotten wood (Esteve-Raventós

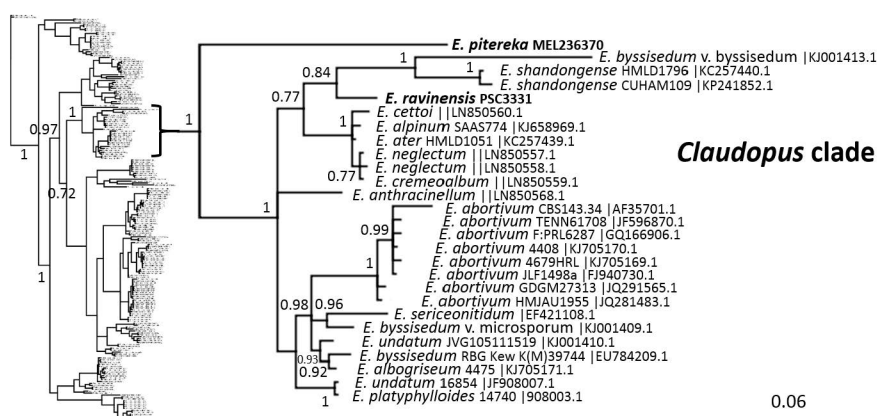
& Ortega 2003). *Entoloma exiguum* has been found amongst plant detritus under herbaceous plants on half-flooded calcareous soils. All three have distant lamellae that are sometimes forked and their basidia are smaller than those of *E. ravinense* (Table 2). *Entoloma exiguum* differs from these in having somewhat larger spores and sac-like basidia. Both *E. alliodorum* and *E. exiguum* have clamp connections, whereas none were found in *E. ravinense*.

*Entoloma jahnii* grows on rotten wood of deciduous trees. It differs from *E. ravinense* in its distant lamellae, larger spores, smaller basidia and presence of clamp connections (Schafer 2008; Nita & Stefaniak 2010; Jančovičová & Adamčík 2012; Noordeloos 2012). *Entoloma parasiticum*, as its name suggests, is parasitic on mushrooms although it is also found on dead wood. Watling & Gregory (1989) report it growing on *Cantharellus cibarius* Fr. and *Polyporus squamosus* (Huds.) Fr., as well as on rotten wood, vegetable debris and ‘naked soil’. It has clamp connections and larger spores than *E. ravinense* but similar sized basidia.

Members of the subgenus *Claudopus* that are not white are *Entoloma byssisedum*, *E. pseudoparasiticum* Noordel., *E. depluens* (Batsch:Fr.) Hesl., *E. ollare* E.Ludwig & T.Rödig and *Entoloma alpinum* Xiao L. He, W.H.Peng & B.C.Gan.

All European collections of *Entoloma byssisedum* are reported as having pale grey or brown pilei, though pileus diameters vary: from 3–11 mm (Noordeloos 1988) to 5–35 ( $-60$ ) mm (Noordeloos 2012). Lamellae are described as crowded,  $L = 10\text{--}25$ ; spores  $9.5\text{--}12 \times 6.5\text{--}8$   $\mu\text{m}$ ,  $Q = 1.3\text{--}1.7$  ( $-1.85$ ), mean  $Q = 1.45$  (Noordeloos 1988); basidia  $22\text{--}37 \times 9\text{--}11$   $\mu\text{m}$  (Noordeloos 1988); cheilocystidia absent but clamp connections present. Thus *E. ravinense* differs from *E. byssisedum* in pileus colour, number of lamellae, basidia size and absence of clamp connections (Table 2). Horak (2008) described collections from New Zealand of *Claudopus byssisedum* as whitish or greyish, with pileus 3–10 mm and with similar dimensions of spores and basidia to the





**Fig. 10.** Phylogram from Bayesian analysis of *Entoloma* ITS1, 5.8S rRNA and ITS2 sequences group *E. ravinense* and *E. pitereka* in the *Claudopus* clade. Figures show the posterior probability of relevant branches. The scale of substitutions per site applies only to the *Claudopus* clade. Accession numbers are for GenBank | and EMBL ||. The phylogram is rooted to the GenBank sequence for *E. sphagnetii* Naveau [KC710061.1].

European collections, although he reported that clamp connections were absent. *Entoloma byssisedum* has been found and collected in Western Australia (Hilton 1988). The two collections have been examined. In the absence of fuller descriptions of macroscopic characters it is not possible to determine differences with other taxa. However, the dimensions of the basidia conform with Horak's measurements (2008). Molecular data for European collections of *Entoloma byssisedum* show that it and *E. ravinense* are different species. In the absence of molecular data for the New Zealand and Australian collections, it is not possible to determine whether they are the same as the European species.

Other pleurotoid species of *Entoloma* are variously different from *E. ravinense*. *Entoloma pseudoparasiticum* has pale brown pilei and stipes and is parasitic on *Cantharellus cibarius* and *Craterellus lutescens* (Pers.) Fr. (Noordeloos 1987). *Entoloma depluens* is grey, and has cystidia and clamp connections. *Entoloma ollare* is greyish to cream-beige, has distant gills, slightly larger spores but much smaller basidia than *E. ravinense*. *Entoloma ollare* is unusual as having been found only indoors in pots of exotic plants: *Clivia* sp., *Ficus benjamina* L. and *Araucaria heterophylla* (Salisb.) Franco (Mleczko & Ociepa 2007). *Entoloma repens* Petch has been recorded from Tanzania and Sri Lanka (Pegler 1986). It is grey becoming whitish, has widely spaced gills and much smaller spores and basidia. *Entoloma alpinum* from Sichuan Province, China is pale straw

yellow, has considerably larger spores, has 2-spored basidia and grows on soil (He et al. 2015).

*Entoloma ravinense* is a rare fungus, found in a specialised environment on very rotten, shed bark of *Eucalyptus cladocalyx*. In spite of intensive surveys in various localities in Flinders Chase National Park it has not been found at any other site. With its remnant vegetation the Ravine des Casoars is an area of significant mycological interest.

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### Key to the Australian species of pleurotoid entolomas

1. Fruit bodies pale grey, grey-brown ..... *Entoloma byssisedum*
- 1: Fruit bodies white
2. Fruit bodies growing on undersides of granitic rocks; fruit bodies sticky
3. Basidiospores 4–5-angled; pileocystidia not subcapitate to capitate ..... *Claudopus rupestris*
- 3: Basidiospores 5–6-angled; pileocystidia subcapitate to capitate
4. Basidia smaller, 23.6–33.6 × 8.0–11.5 µm ..... *Claudopus viscosus*
- 4: Basidia larger, 32.7–38.3 × 9.8–13.2 µm ..... *Claudopus minutoincanus*
- 2: Fruit bodies growing on woody substrates; fruit bodies not sticky
5. Fruit bodies small, 1–15 mm diameter; lamellae subdistant; pileus margins becoming plane ..... *Entoloma pitereka*
- 5: Fruit bodies larger, 5–63 mm diameter; lamellae close; pileus margins remaining inrolled ..... *Entoloma ravinense*

**Table 1.** Measurements of macroscopic characters, substrates and sources of data for known pleurotoid species of *Entoloma*. \* = measurements made by PSC; n.d. = no data.

Species	Pileus dimens. (mm)	Colour	Cover	Lamella spacing	Lamellulae	Substrate
<i>Entoloma ravinense</i> <sup>1</sup>	5–63	white	downy-woolly to tomentose	close, L = 25–60	3	undersurface of fallen bark
<i>E. ravinense</i> (PSC3960) <sup>2</sup>	6–40	white	downy-woolly to tomentose	close	4	undersurface of fallen bark
<i>E. ravinense</i> (PSC4229) <sup>3</sup>	7–30	white	woolly-tomentose	close, L = 11–20	3–4	undersurface of fallen bark
<i>E. pitereka</i> <sup>4</sup>	1–15	white	covered with aeriferous fibrils or tomentose	subdistant	1?	underside of rotten wood
<i>E. pitereka</i> (G&R1733) <sup>5</sup>	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
<i>E. pitereka</i> (G&R1747) <sup>6</sup>	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
<i>E. jabnii</i> <sup>7</sup>	1–15	white to pale pink	finely white hairy-tomentose all over	distant	n.d.	rotten wood
<i>E. jabnii</i> <sup>8</sup>	1–15	white	n.d.	distant	n.d.	rotten wood
<i>E. jabnii</i> <sup>9</sup>	2–10	white, pinkish with age	hairy then tomentose	L = 8–18	1–3	rotten wood
<i>E. parasiticum</i> <sup>10</sup>	3–9	white	entirely tomentose	distant	n.d.	on bark of dead wood
<i>E. parasiticum</i> <sup>11</sup>	3–9	white	entirely tomentose	distant	n.d.	on living mosses, on very rotten bark of coniferous trees, on fungi
<i>E. albotomentosum</i> <sup>11</sup>	2–10	white	silvery white fibrillose when young	very distant, L = 7–10 (–12)	n.d.	on rotten leaf-sheaths and debris of sedges and grasses, marshy places
<i>E. albotomentosum</i> <sup>8</sup>	2–10	white	fibrillose-tomentose	distant	n.d.	on debris of sedges and grasses, marshy places
<i>E. albotomentosum</i> <sup>12</sup>	1.5–5.4	white, turning pinkish	silvery white fibrillose then a centre bundle of agglutinated hairs	very distant, L = 5–14	n.d.	on debris of herbaceous plants
<i>E. exiguum</i> <sup>13</sup>	2–5	white	uniformly hairy-furfuraceous	distant, L = 7–12	0–1	among plant detritus
<i>E. exiguum</i> <sup>7</sup>	2–5	white	uniformly hairy-furfuraceous	distant, L = 7–12	0–1	among plant detritus in half-flooded, calcareous soils
<i>E. alliodorum</i> <sup>14</sup>	3–8 (–10)	white	finely fibrillose to pubescent	moderately distant, L = 15–22	n.d.	on organic debris, among mosses
<i>E. alliodorum</i> <sup>7</sup>	3–8 (–10)	white	finely fibrillose to pubescent	moderately distant, L = 15–22	n.d.	on organic debris, among mosses
<i>Claudopus rupestris</i> <sup>15</sup>	1–4	white, with very pale yellowish tinges	minutely matted-fibrillose, glistening, sticky	distant, L = 5–8	1	undersurface of rocks
<i>C. viscosus</i> <sup>15</sup>	1.5–11	at first white then off-white to pinkish-white	entirely matted-fibrillose	close then subdistant to distant	1–3	rhizoids of moss gametophytes
<i>C. minutincanus</i> <sup>15</sup>	1–3	whitish, hint of yellowish-white	matted fibrillose, glistening, sticky	close	n.d.	thin layer of soil under rock
<i>E. byssisedum</i> <sup>10</sup>	3–11	pale grey or brown	radially fibrillose to hirsute	crowded, L = 10–25	0–5	on ground, mosses, rotten leaves, wood
<i>E. byssisedum</i> <sup>11</sup>	5–35	pale grey or brown	radially fibrillose to hirsute	rather distant to fairly crowded, L = 10–25	0–5	dead organic material, rotten wood, on ground



Species	Pileus dimens. (mm)	Colour	Cover	Lamella spacing	Lamellulae	Substrate
<i>E. byssisedum</i> <sup>8</sup>	3–35 (–60)	pale grey to pale brown	densely covered with silvery fibrils	crowded, L = 10–25	n.d.	terricolous or on dead plant remains
<i>E. byssisedum</i> <sup>16</sup>	n.d.	n.d.	n.d.	n.d.	n.d.	rotten wood
<i>E. byssisedum</i> <sup>17</sup>	n.d.	white	floccose	n.d.	n.d.	old wood
<i>E. byssisedum</i> (as <i>C. byssisedus</i> ) <sup>18</sup>	3–10	whitish or greyish pale grey to pale brown	radially fibrillose or silky	L = 16–20  moderately distant to distant, L = 10–22	to 3	on rotting bark and wood
<i>E. byssisedum</i> var. <i>microsporum</i> <sup>7</sup>	to 20	pale grey- brown	arachnoid-fibrillose tomentum	distant	0–5	terricolous or on dead plant remains
<i>E. pseudoparasiticum</i> <sup>19</sup>	2–10	pale brown	subtomentose	distant	n.d.	parasitic on <i>Cantharellus cibarius</i> and <i>Craterellus lutescens</i>
<i>E. pseudoparasiticum</i> <sup>11</sup>	2–10	pale brown	subtomentose	distant	n.d.	parasitic on <i>Cantharellus cibarius</i> and <i>Craterellus lutescens</i>
<i>E. depluens</i> <sup>10</sup>	4–20	pale grey (brown)	densely white-fibrillose, at centre often tomentose	rather distant <sup>20</sup>	n.d.	on mosses, wood or on ground
<i>E. depluens</i> <sup>11</sup>	6–20	greyish seemingly white	strongly aeriferous surface	rather crowded L = 15–30	1–3	on rotten wood
<i>C. repens</i> <sup>21</sup>	4–6	grey becoming whitish	finely floccose	widely spaced	occasional	underside of rotting logs
<i>E. ollare</i> <sup>22</sup>	to 9	greyish to cream and cream-beige	tomentose, sparse short hairs	not crowded	n.d.	in pot with <i>Araucaria heterophylla</i>
<i>E. ollare</i> <sup>7</sup>	2.5–10	pale grey then cream	entirely finely tomentose	subdistant	n.d.	in pot with <i>Araucaria heterophylla</i>
<i>E. alpinum</i> <sup>23</sup>	9–30	pale straw yellow	Subtomentose felted patches or fibrils when fresh, slightly pallescent on drying	subdistant	2–3	On soil in partially disturbed and open grassland

**Data Sources.** <sup>1</sup> Notes with herbarium collection PSC3331, AD-C 56995; <sup>2</sup> Notes with herbarium collection PSC3960, AD-C 58774; <sup>3</sup> Notes with herbarium collection PSC4229, AD-C 59843; <sup>4</sup> Noordeloos & Gates (2012); <sup>5</sup> Collection Gates & Ratkowsky 1733, MEL 2363720; <sup>6</sup> Collection Gates & Ratkowsky 1747, MEL 2363723; <sup>7</sup> Noordeloos (2004); <sup>8</sup> Noordeloos (2012); <sup>9</sup> Jančovičová & Adamčík (2012); <sup>10</sup> Noordeloos (1988); <sup>11</sup> Noordeloos (1992); <sup>12</sup> Halama (2011); <sup>13</sup> Esteve-Raventós & de la Cruz (1998); <sup>14</sup> Esteve-Raventós & Ortega (2003); <sup>15</sup> Largent et al. (2011); <sup>16</sup> Hilton (1983); <sup>17</sup> Daams (1978); <sup>18</sup> Horak (2007); <sup>19</sup> Noordeloos (1987); <sup>20</sup> Watling & Gregory (1989); <sup>21</sup> Pegler (1986); <sup>22</sup> Mieczko & Ociepa (2007); <sup>23</sup> He et al. (2015).

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**Table 2.** Measurements of microscopic characters and sources of data for known pleurotoid species of *Entoloma*. \* = measurements made by PSC; n.d. = no data; av. = average.

Species	Spore dimensions (mm)	Mean spore dimens. (µm)	Q range	Q mean	Number: spore angle	Basidia (µm)
<i>Entoloma ravinense</i> Type (PSC3331) <sup>1</sup>	*8.0–10.5 × 6.5–8.0	*8.26 × 6.95	*1.11–1.44 (–1.56)	*1.31	*5–6 (–7)	*38–46 × 8–11 (–12)
<i>Entoloma ravinense</i> (PSC3960) <sup>2</sup>	*8.0–11.0 × 6.5–8.0 (–9.6)	*9.6 × 7.15	*1.06–1.44 (–1.56)	*1.26	*5–6 (–7)	*36.8–48.8 × 9.5–12.5
<i>Entoloma ravinense</i> (PSC4229) <sup>3</sup>	*8.0–11.0 × 6.5–8.0	*9.12 × 7.275	*1.1–1.4 (–1.5)	*1.27	*5–6	*34–42 × 10–12
<i>E. pitereka</i> Holotype <sup>4</sup>	*8.0–12.0 × 6.5–8.0	*9.92 × 7.0	*1.11–1.75	*1.42	5–6	*28–32.8 × 9.6–11.2
<i>E. pitereka</i> (G&R1733) <sup>5</sup>	*8.0–11.0 × 6.5–8.0	*9.59 × 7.05	*1.0–1.6	*1.36	5–6	*28–32 (–36) × 11–13 (–14)
<i>E. pitereka</i> (G&R1747) <sup>6</sup>	*8.0–11.0 × 6.5–8.0 (–9.0)	*9.52 × 7.43	*1.09–1.5	*1.39	5–6	*26–38 × 9–12
<i>E. jabnii</i> <sup>7</sup>	(9–) 10–14 (–15) × 7.5–11 (–11.5)	n.d.	1.0–1.5 (–1.55)	1.2–1.3	5–6	30–47 × 10–14
<i>E. jabnii</i> <sup>8</sup>	9.5–13 (–15) × 7.5–10 (–11.5)	n.d.	n.d.	n.d.	5–6	n.d.
<i>E. jabnii</i> <sup>9</sup>	(9–) 10.45–12.9 (–14.8) × (7.5–) 8.1–9.4 (–10.8)	11.7 × 8.8	(1.14–) 1.22– 1.45 (1.63)	1.33	5–6 (–7)	(25–) 28.5–36 (–41) × 11.5–13 (–15)
<i>E. parasiticum</i> <sup>10</sup>	9.5–11.0 × 8.0–9.5	n.d.	1.1–1.2	1.15	4–6	24–45 × 10–15
<i>E. parasiticum</i> <sup>11</sup>	9.5–12.5 × 8.0–10.5 (–11.0)	n.d.	1.1–1.4	n.d.	5–6	n.d.
<i>E. albotomentosum</i> <sup>11</sup>	9.0–12.5 × 6.5–8.0	n.d.	1.1–1.5	n.d.	4–6	n.d.
<i>E. albotomentosum</i> <sup>8</sup>	9–12.5 × 6–8	n.d.	n.d.	n.d.	4–6	n.d.
<i>E. albotomentosum</i> <sup>12</sup>	(7.23–) 8.86–9.05 (–12.14) × (5.89–) 6.95–7.09 (–8.87)	n.d.	(0.97–) 1.27– 1.29 (–1.64)	n.d.	4–6	(25.14–) 28.86–30.55 (–36.39) × (9.85–) 11.75–12.64 (–14.50)
<i>E. exiguum</i> <sup>13</sup>	9.4–12 × 6.4–8.3	10.8 × 7.4	1.15–1.75	1.45	6–8	25–32 × 11–12.5 (utriform)
<i>E. exiguum</i> <sup>7</sup>	(9.5–) 10–12 × 6.5–8.5	n.d.	1.15–1.8	1.5	6–8	25–35 × 10–12.5
<i>E. alliodorum</i> <sup>14</sup>	8.8–10.9 × 6.2–7.7	9.8 × 7	n.d.	1.4	6–7	30–36 (–42) × 11.5–14
<i>E. alliodorum</i> <sup>7</sup>	8.8–9.8–10.9 × 6.2–7–7.7	n.d.	1.44		6–7	30–36 (–42) × 11.5–14
<i>Claudopus rupestris</i> <sup>15</sup>	6.5–9.2 × 5.9–8.0	8.1 × 6.8	1.0–1.36	1.18	4–5	20.8–31.8 × 8.0–11.5 (av. 27.19 × 9.7)
<i>C. viscosus</i> <sup>15</sup>	7.7–12.0 × 5.3–7–9	9.8 × 6.7	1.22–1.88	1.47	5–6	23.6–33.6 × 8.0–11.5 (av. 29.5 × 10.0)
<i>C. minutincanus</i> <sup>15</sup>	7.4–11.4 × 6.3–9.6	9.01 × 7.4	1.08–1.44	1.22	6	32.7–38.3 × 9.8–13.3
<i>E. byssisedum</i> <sup>10</sup>	(9.5–) 10.0–12.0 (–12.5) × 6.5–8.0	n.d.	1.3–1.7 (–1.85)	1.45	irregular	22–37 × 9–11.5
<i>E. byssisedum</i> <sup>11</sup>	9.5–12 (–12.5) × 6.5–8	n.d.	1.3–1.8	n.d.	irregular	n.d.
<i>E. byssisedum</i> <sup>8</sup>	9.5–12 × 6.5–8	n.d.	n.d.	n.d.	many	n.d.
<i>E. byssisedum</i> <sup>16</sup>	*8.0–10.8 × (5.6–) 6.0–7.2 (–8.0)	*9.34 × 6.79	*1.18–1.53	*1.38	n.d.	*25–34 × 8–11
<i>E. byssisedum</i> <sup>17</sup>	*8.0–10.4 × 6.0–7.2	*8.93 × 6.42	*1.21–1.59	*1.39	n.d.	*27–34 × (8–)10–12
<i>E. byssisedum</i> (as <i>C. byssisedus</i> ) <sup>18</sup>	8–9 × 6–7.5	n.d.	n.d.	n.d.	5–6	27–36 × 10–12
<i>E. byssisedum</i> var. <i>microsporum</i> <sup>7</sup>	7.5–9.5 × 5.5–7.5	8.7 × 6.7	1.15–1.5	1.3	5–6	32–45 × 10–14
<i>E. pseudoparasiticum</i> <sup>19</sup>	7.5–10 (–10.5) × 6.0–7.5	8.5–9.0 × 6.5–7.0	n.d.	n.d.	5–6	30–40 × 8.5–14
<i>E. pseudoparasiticum</i> <sup>11</sup>	7.5–10 (–10.5) × 6.0–7.5	n.d.	n.d.	n.d.	5–6	n.d.
<i>E. depluens</i> <sup>10</sup>	8.0–9.0 (–10.0) × 6.0–7.0 (–8.0)	n.d.	1.2–1.5	1.3	5–7	n.d.



Species	Spore dimensions (mm)	Mean spore dimens. (µm)	Q range	Q mean	Number: spore angle	Basidia (µm)
<i>E. depluens</i> <sup>11</sup>	8.5–11 × 7–7.5	n.d.	1.1–1.5	1.3	5–7	n.d.
<i>C. repens</i> <sup>20</sup>	5–7.5 × 4–5.5	6 × 4.5		1.32	5–6	21–28 × 6–7
<i>E. ollare</i> <sup>21</sup>	8–12 × 6–9	10.1 × 7.4	1.3–1.8	1.5	5–7 (–8)	16–28 × 6–11
<i>E. ollare</i> <sup>7</sup>	8.5–13 × 6–9	n.d.	1.2–1.8	1.4–1.5	5–7 (–8)	20–40 × 6–12
	11.5–15 (–16)			1.28		
<i>E. alpinum</i> <sup>22</sup>	× (8.5–) 9–11.5 (–13.5)	n.d.	1.09–1.43	± 0.03	6–10	34–40 × 11–12 (2-spored)

**Data Sources.** <sup>1</sup> Notes with herbarium collection: PSC3331, AD-C 56995; <sup>2</sup> Notes with herbarium collection: PSC3960, AD-C 58774; <sup>3</sup> Notes with herbarium collection: PSC4229, AD-C 59843; <sup>4</sup> Collection Noordeloos & Gates E 2081, HO 564359; <sup>5</sup> Collection Gates & Ratkowsky 1733, MEL 2363720; <sup>6</sup> Collection Gates & Ratkowsky 1747, MEL 2363723; <sup>7</sup> Noordeloos (2004); <sup>8</sup> Noordeloos (2012); <sup>9</sup> Jančovičová & Adamčík (2012); <sup>10</sup> Noordeloos (1988); <sup>11</sup> Noordeloos (1992); <sup>12</sup> Halama (2011); <sup>13</sup> Esteve-Raventós & de la Cruz (1998); <sup>14</sup> Esteve-Raventós & Ortega (2003); <sup>15</sup> Largent et al. (2011); <sup>16</sup> Collection Hilton s.n., PERTH 00917354; <sup>17</sup> Collection Daams s.n., PERTH 00938424; <sup>18</sup> Horak (2007); <sup>19</sup> Noordeloos (1987); <sup>20</sup> Pegler (1986); <sup>21</sup> Mleczko & Ociepa (2007); <sup>22</sup> He et al. (2015).

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